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Contribution to the Geothermal Exploration of Eburru Field

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Abstract: With the increasing global demand for clean energy, the use of geothermal energy is expected to increase in the future. The East African countries, especially those crossed by the East African Rift System, have a significant potential in geothermal energy. This paper comes therefore to bring a contribution in the exploration of this clean energy in Africa especially in the region of Eburru in Kenya. Eburru is one of the geothermal fields in Kenya, with the estimated capacity of around 250Mwe. This paper presents the results and interpretations of the processing and the analysis of some geophysical survey data especially gravity, geochemical data and geological data acquired during our field survey. For the geology studies, a geological map showing structures trending in North-South direction and also several geothermal manifestations like fumaroles, hot ground and craters were mapped. From the geophysical studies, a heat source located at 1500 meters below masl and the reservoir is estimated between 1000 above masl to 1000 below masl. The cap rock of this prospect is between 1000 to 2000 meters above masl and the density increases from the West to the East of the prospect. The interpretation of the fluids geothermometers gave the calculated temperature between 255-270 Celsius degree. By combining and interpreting the different results obtained, we found that the Eburru, with the reservoir temperatures ranged between 255-270°C, has the potential to provide geothermal energy for various utilization.

Keywords: Geothermal Energy, Exploration, Eburru

1. Introduction

The East African Rift System is endowed with a geothermal energy resource potential of about 20 GW that can be used for power generation and direct use application.

The geothermal field of Eburru is located in the great East African Rift System (EARS) which is a major tectonic structure stretching about 6100 km starting from the Red Sea in the north to Mozambique in the south. The Rift starts from a triple junction, evident in Ethiopia; at this point, two branches are in contact with the Red Sea and the Gulf of Eden while the third passes through Ethiopia to the south. [1, 2]

The East African Rift System (EARS) stretches though Eritrea, Ethiopia, Kenya, and all the way down to Mozambique (Figure 1). The great Africa Rift system forms more or less a linear like zone where the continental plate is being pulled apart with the rifting between. A widened mantle plume probably began under east Africa creating the three arms which are: The East Africa Rift, The Gulf of Eden Rift and The Red Sea Rift. The heat flow from the asthenosphere along the rift zones led to volcanism and the formation of domes, as can be seen in Olkaria to the south of Eburru (Figure 1). The eastern branch is believed to be much older and is considered to have developed about 13-23 million years earlier than the western branch; this is supported by the discovery of preserved vertebrate fossils and volcanic ash which are believed to be about 23 million years old [1, 2].

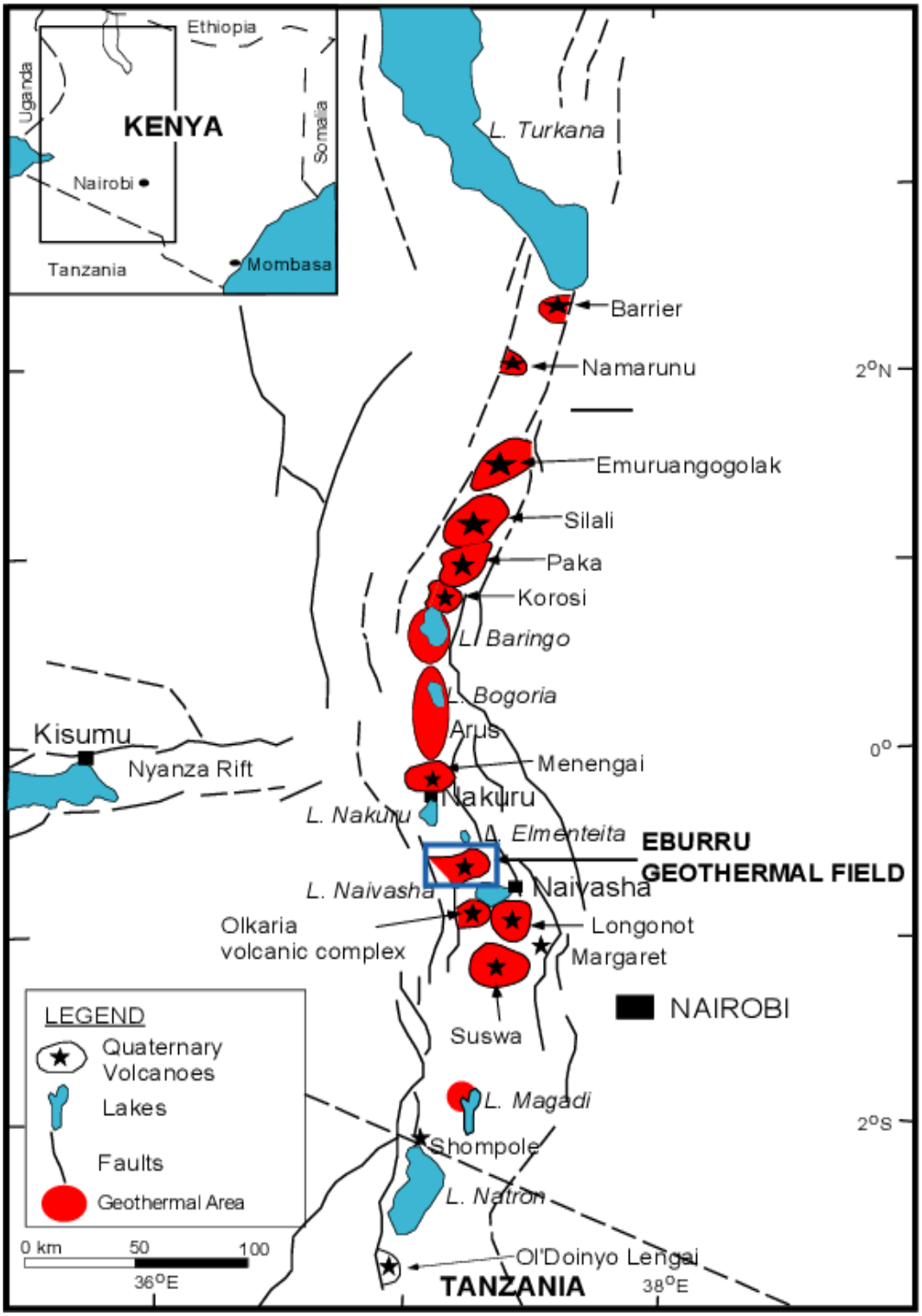

Figure 1. *Map showing location of Eburru geothermal field [1].*

2. Methodology

The methodology used to achieve this noble work was availed by Africa Geothermal Center of Excellence (AGCE) through resource materials including data sets derived from the field (geophysical, geochemical and geological survey) internet and previous work data. Programs and softwares such as Golden Software Surfer 13, ArcGIS Desktop 10.1 and Microsoft Excel 13 were used to process and analyze the data acquired during the field survey (Geochemistry, Geophysics and Geology). After that, maps were produced for: surface temperature, Carbone dioxide distribution, Radon distribution and gravity (Complete Bouguer Anomaly). So we tried to do the interpretation by integrating all those data sets and maps produced.

3. Geology

3.1. Volcanology and Geology of Eburru

Eburru is a complex volcanic located in the Kenya Rift. Eburru volcanic complex is made of two topographic highs in the west and the east. Each of these topographic entities is a ring structure. The west ring structure has an approximate diameter of 2 km. [2]

Other geologic structures in west Eburru are normal faults of age between 0.8 Ma and 0.4 Ma. This west side of Eburru are characterized by the presence of lineaments which are curved towards the axis of the Rift Valley. No geological map of the West Eburru because of pyroclastic events and vegetated forest.

The east ring structure has been referred to as caldera-like Close examination of the satellite image and aerial photographs reveal the presence of a ring structure associated with eastern Eburru. Eburru hill, the second highest peak in the volcanic complex, is located on the northeast margin of the ring structure and rises to about 2600 masl [2].

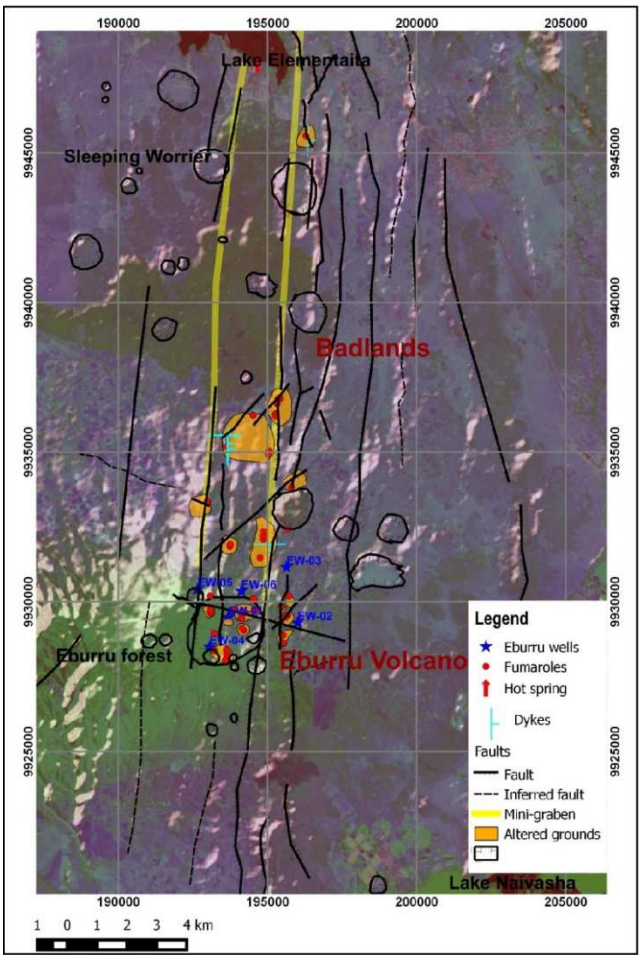

Figure 2. *Map showing structural geology of Eburru [2].*

3.2. Stratigraphy of Eburru

The stratigraphic section of Eburru based on surface rock outcrops is separated into older and younger lava.

The oldest to the youngest section is composed of 1) older pantellerite, 2) older trachyte, 3) older basalts, 4) older pyroclastic sequence.

The younger sequences are 1) younger trachyte, 2) younger basaltic unit, 3) younger pyroclastic sequence, 4) younger pantelleritic unit. These younger sequences are between 0.4 Ma and 100 years old. [2]

The 0.8 Ma to 0.4 Ma faults offset the older lava and pyroclastic sequences. The estimated age for these lavas is between 1.2 Ma and 0.4 Ma. The younger sequences are 1) younger trachyte, which overlays the older pyroclastics and is not faulted and outcrops only in eastern Eburru, 2) younger basaltic unit, which is not faulted and caps the older basaltic unit, 3) younger pyroclastics sequence, which partially covers eastern and western Eburru and is not faulted, 4) younger pantelleritic unit, which in some locations seems to be contemporaneous with the pyroclastics, and in others overlays the pyroclastics. These younger sequences have an age between 0.4 Ma and 100 years. [2]

3.3. Geological Structure of Eburru

In Eburru, several faults are identifiable. They date from 0.8 Ma to 0.4 Ma. [2]

3.4. Eruptive Centres of Eburru

Eburru hill which culminates in 2600 meters. There are several craters. [2]

3.5. Hydrothermal Activity

Fumerols associated with faults and crater (Velador et al.; 2003) Hot ground. The altered zones contain secondary minerals of kaolinite, smectite, native sulfur, and sinter which implies high heat flow from the source. [2]

Below about 1500masl for wells within the ring structure occurs epidote, garnet, calcite, biotite, illite, vermiculite and chlorite which indicates temperatures of more than 220°C.

Low temperature secondary minerals occur below 2000 masl. [2]

4. Geochemestry

Water and steam geothermometers are collectively termed chemical geothermometers. During the ascent of geothermal waters from a deep reservoir to the surface, they may cool by conductive heat loss as they travel through cooler rocks or by boiling because of decreasing hydrostatic head [5-15].

From the soil gas sampling, distribution maps of CO_2, and Rn were produced. From the distribution maps the area in the southwest has high concentrations of Randon and Carbon dioxide. The presence of radon indicates the decay of magmatic material. These high concentrations of radon and carbon dioxide help to map out the heat source and the presence of fractures. In addition, these areas with high concentration of Radon and Carbondioxide also have high surface temperatures probably meaning presence of the heat source underneath. [3, 6-11]

4.1. Radon Distribution

Table 1. *Raddon data.*

No.	Eastings	Northings	Rn-222	No.	Eastings	Northings	Rn-222	No.	Eastings	Northings	Rn-222
1	198000	9930000	411	34	195850	9928700	427	67	196950	9927600	489
2	197750	9929950	718	35	195850	9929000	230	68	197250	9927600	340
3	197400	9929900	1764	36	195850	9929300	681	69	197550	9927600	223
4	197100	9929820	829	37	195850	9929650	594	70	197450	9930250	364
5	196850	9929820	1160	38	195850	9929950	290	71	197150	9930700	452
6	196350	9929800	681	39	195875	9930250	335	72	196800	9930165	722
7	196250	9929750	720	40	195850	9930575	620	73	196500	9930150	1100
8	195930	9929680	3562	41	196725	9937150	196	74	196200	9960100	931
9	195680	9929590	1583	42	196350	9936825	216	75	195900	9930075	1266
10	195400	9929450	63258	43	195875	9936800	300	76	195750	9930050	766
11	193000	9928550	60063	44	195375	9936775	700	77	195450	9930000	853
12	193550	9928750	1137	45	194450	9936400	670	78	195150	9930000	1091
13	193850	9928800	597	46	194400	9936700	1242	79	194850	9930000	321
14	194200	9928750	373	47	194050	9935850	1591	80	193000	9949000	100
15	194550	9928850	60	48	193550	9936050	254	81	194350	9946850	370
16	194750	9928850	183	49	193200	9936350	3000	82	196150	9944250	300
17	194990	9928950	854	50	192900	9936250	309	83	195300	9944500	580
18	195220	9929050	320	51	194750	9928450	319	84	195250	9943250	370
19	195510	9929150	1526	52	194750	9928450	2218	85	196200	9942500	280
20	195760	9929250	230	53	195050	9928475	398	86	196600	9942000	287
21	194950	9925950	126	54	195400	9928500	433	87	196500	9941300	140
22	194650	9926550	1025	55	195700	9928500	548	88	196200	9940100	380
23	194350	9928300	1628	56	196000	9928500	375	89	196250	9939100	418
24	194300	9928650	301	57	196300	9928500	102	90	192550	9930575	689
25	194300	9928950	104	58	196400	9928800	377	91	193000	9930600	870
26	194250	9929300	460	59	196700	9928750	281	92	193350	9930700	1832
27	194550	9929650	567	60	197000	9928750	683	93	193700	9930650	245
28	194450	9929900	1715	61	195150	9927350	1727	94	194000	9930650	261
29	194250	9930200	193	62	195450	9927450	18762	95	194200	9930650	393
30	194450	9930500	9237	63	195750	9927500	11016	96	194450	9930675	253
31	195900	9927800	503	64	196050	9927600	1685	97	194750	9930700	470
32	195900	9928100	488	65	196350	9927600	344	98	195050	9930750	890
33	195900	9928400	854	66	196650	9927600	393	99	196200	9930815	1266

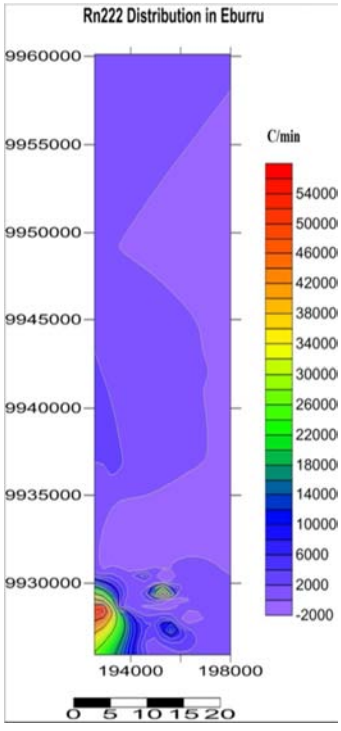

Figure 3. *Map showing Radon distribution.*

4.2. Carbon Dioxide Distribution

Table 2. *Carbon dioxide sampling data.*

No.	Eastings	Northings	CO_2 (%)	No.	Eastings	Northings	CO_2 (%)	No.	Eastings	Northings	CO_2 (%)
1	198000	9930000	1,2	34	195850	9928700	0,5	67	196950	9927600	0,7
2	197750	9929950	1,4	35	195850	9929000	0,3	68	197250	9927600	0,5
3	197400	9929900	2,4	36	195850	9929300	0,6	69	197550	9927600	0,3
4	197100	9929820	1,4	37	195850	9929650	0,5	70	197450	9930250	0,6
5	196850	9929820	1,9	38	195850	9929950	0,2	71	197150	9930700	0,7
6	196350	9929800	0,9	39	195875	9930250	0,3	72	196800	9930165	0,9
7	196250	9929750	0,7	40	195850	9930575	1,2	73	196500	9930150	1,1
8	195930	9929680	5,6	41	196725	9937150	0,2	74	196200	9960100	1
9	195680	9929590	2,6	42	196350	9936825	0,3	75	195900	9930075	1,1
10	195400	9929450	36,7	43	195875	9936800	0,4	76	195750	9930050	0,4
11	193000	9928550	25	44	195375	9936775	0,8	77	195450	9930000	0,6
12	193550	9928750	1,8	45	194450	9936400	0,9	78	195150	9930000	0,8
13	193850	9928800	0,6	46	194400	9936700	1,1	79	194850	9930000	0,5
14	194200	9928750	0,7	47	194050	9935850	1,3	80	193000	9949000	0,2
15	194550	9928850	0,2	48	193550	9936050	0,4	81	194350	9946850	0,5
16	194750	9928850	0,5	49	193200	9936350	2,7	82	196150	9944250	0,4
17	194990	9928950	0,9	50	192900	9936250	0,4	83	195300	9944500	0,6
18	195220	9929050	0,4	51	194750	9928450	0,5	84	195250	9943250	0,7
19	195510	9929150	1,6	52	194750	9928450	1	85	196200	9942500	0,4
20	195760	9929250	0,6	53	195050	9928475	0,6	86	196600	9942000	1,8
21	194950	9925950	0,3	54	195400	9928500	0,8	87	196500	9941300	0,8
22	194650	9926550	0,8	55	195700	9928500	0,7	88	196200	9940100	0,6
23	194350	9928300	1,8	56	196000	9928500	0,6	89	196250	9939100	0,7
24	194300	9928650	0,6	57	196300	9928500	0,2	90	192550	9930575	0,7
25	194300	9928950	0,3	58	196400	9928800	0,5	91	193000	9930600	1,2
26	194250	9929300	0,9	59	196700	9928750	0,3	92	193350	9930700	2,1
27	194550	9929650	1	60	197000	9928750	0,7	93	193700	9930650	0,3
28	194450	9929900	1,5	61	195150	9927350	1,8	94	194000	9930650	0,3
29	194250	9930200	0,2	62	195450	9927450	13,2	95	194200	9930650	0,5
30	194450	9930500	8,6	63	195750	9927500	20,8	96	194450	9930675	0,4
31	195900	9927800	0,6	64	196050	9927600	1,5	97	194750	9930700	0,8
32	195900	9928100	0,7	65	196350	9927600	0,5	98	195050	9930750	1
33	195900	9928400	0,8	66	196650	9927600	0,4	99	196200	9930815	1,3

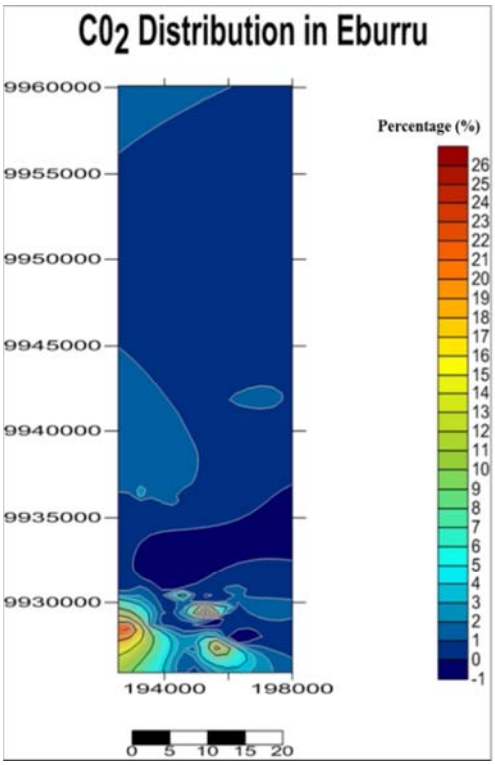

Figure 4. *Map showing carbon dioxide distribution.*

4.3. Surface Temperature Distribution

Table 3. *Surface temperature data.*

No.	Eastings	Northings	Grnd temp	No.	Eastings	Northings	Grnd temp	No.	Eastings	Northings	Grnd temp
1	198000	9930000	22,2	34	195850	9928700	22,1	67	196950	9927600	18,8
2	197750	9929950	15	35	195850	9929000	21,5	68	197250	9927600	23
3	197400	9929900	24,6	36	195850	9929300	21,2	69	197550	9927600	21,3
4	197100	9929820	26	37	195850	9929650	24,6	70	197450	9930250	20,7
5	196850	9929820	21,5	38	195850	9929950	22,2	71	197150	9930700	18,6
6	196350	9929800	22,5	39	195875	9930250	21,8	72	196800	9930165	20
7	196250	9929750	21,8	40	195850	9930575	20,5	73	196500	9930150	22,2
8	195930	9929680	25,9	41	196725	9937150	21,5	74	196200	9960100	20,2
9	195680	9929590	20,8	42	196350	9936825	21,6	75	195900	9930075	19,1
10	195400	9929450	41,4	43	195875	9936800	25	76	195750	9930050	21,5
11	193000	9928550	60,4	44	195375	9936775	30,3	77	195450	9930000	25,4
12	193550	9928750	19,4	45	194450	9936400	23,6	78	195150	9930000	13
13	193850	9928800	21,1	46	194400	9936700	34,4	79	194850	9930000	21,3
14	194200	9928750	21,1	47	194050	9935850	29	80	193000	9949000	39,7
15	194550	9928850	20,8	48	193550	9936050	24,2	81	194350	9946850	26,1
16	194750	9928850	20,9	49	193200	9936350	24,7	82	196150	9944250	26
17	194990	9928950	23,4	50	192900	9936250	22,8	83	195300	9944500	25,3
18	195220	9929050	23,5	51	194750	9928450	20,7	84	195250	9943250	31,9
19	195510	9929150	24,2	52	194750	9928450	17,7	85	196200	9942500	26,4
20	195760	9929250	22,2	53	195050	9928475	17,5	86	196600	9942000	21,5
21	194950	9925950	17,1	54	195400	9928500	21,7	87	196500	9941300	29,7
22	194650	9926550	22,9	55	195700	9928500	21	88	196200	9940100	26,8
23	194350	9928300	20,4	56	196000	9928500	24	89	196250	9939100	25,3
24	194300	9928650	21	57	196300	9928500	22,3	90	192550	9930575	19,6
25	194300	9928950	21,9	58	196400	9928800	21,1	91	193000	9930600	19,4
26	194250	9929300	20,4	59	196700	9928750	18,2	92	193350	9930700	22,1
27	194550	9929650	23,9	60	197000	9928750	18,6	93	193700	9930650	21,8
28	194450	9929900	23	61	195150	9927350	25	94	194000	9930650	27,6
29	194250	9930200	23,7	62	195450	9927450	87,8	95	194200	9930650	26,3
30	194450	9930500	35,6	63	195750	9927500	90,8	96	194450	9930675	20,2
31	195900	9927800	19,8	64	196050	9927600	18,9	97	194750	9930700	24,7
32	195900	9928100	18,7	65	196350	9927600	19,9	98	195050	9930750	30,1
33	195900	9928400	19,5	66	196650	9927600	18,1	99	196200	9930815	28,4

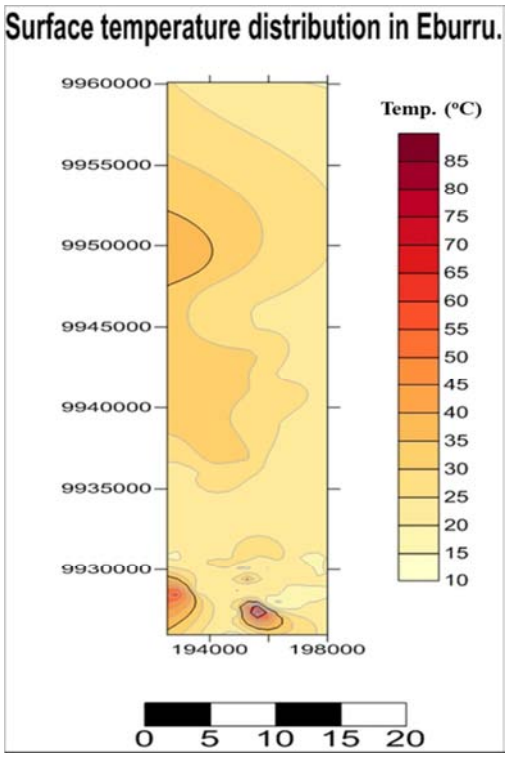

Figure 5. *Map showing surface temperature distribution.*

5. Geophysics (Gravity Surveys)

Table 4. *Complete bouguer Anomaly data.*

No.	Easting	Northing	CBA	No.	Easting	Northing	CBA	No.	Easting	Northing	CBA
1	196310	9928500	-1868,6	132	194700	9928800	-1918,2	263	191300	9934400	-1800,6
2	196060	9928510	-1879,7	133	194660	9928800	-1901,6	264	190900	9934200	-1815,2
3	195815	9928400	-1857,1	134	194600	9928700	-1906,6	265	190400	9934100	-1801,5
4	196290	9928910	-1863,2	135	194600	9928600	-1902,9	266	190400	9934200	-1811,8
5	196255	9928855	-1866,5	136	194700	9928400	-1929	267	190000	9934300	-1812,8
6	196130	9929055	-1869,5	137	194735	9928310	-1929,4	268	190000	9934500	-1794,5
7	196110	9929200	-1865,3	138	194800	9928255	-1927,9	269	191100	9934600	-1890,6
8	196135	9929455	-1871,6	139	194910	9928200	-1921,2	270	191100	9935600	-1907,7
9	196320	9929700	-1857,4	140	195000	9928030	-1911,4	271	191100	9935700	-1920,2
10	196355	9929800	-1840,6	141	194900	9927760	-1941,4	272	190700	9935800	-1914,2
11	196425	9928600	-1884,7	142	194800	9927600	-1946,4	273	190700	9936000	-1915,6
12	196310	9928500	-1869,6	143	195900	9928400	-1879	274	190600	9936400	-1935,9
13	196600	9928800	-1849,5	144	195900	9928200	-1885,5	275	197800	9930500	-1874,5
14	196700	9929000	-1863,2	145	195700	9928200	-1846,6	276	197900	9930300	-1875,5
15	196700	9929100	-1818,8	146	196000	9928200	-1881,4	277	198200	9930060	-1830,2
16	196700	9929200	-1822,2	147	196100	9928100	-1873,7	278	198400	9929800	-1844,7
17	196700	9929400	-1818,7	148	196300	9928200	-1768,9	279	198900	9929300	-1878,7
18	196900	9929800	-1832,4	149	196600	9928100	-1867,6	280	199300	9929100	-1884,8
19	197200	9929700	-1862,5	150	196300	9928000	-1865,2	281	199600	9929900	-1802,6
20	197400	9929800	-1863,9	151	196700	9928000	-1861,1	282	200100	9928800	-1880,9
21	197500	9930255	-1862,1	152	196060	9929500	-1869,8	283	200600	9928000	-1865,5
22	197500	9930800	-1860,3	153	196000	9929290	-1761	284	201100	9928600	-1877,7
23	197400	9931000	-1869	154	196000	9929000	-1885,2	285	201500	9928400	-1882,6
24	197300	9931200	-1881,6	155	196055	9928940	-1888,8	286	201800	9928200	-1858,3
25	197100	9931500	-1862	156	195900	9928900	-1884,7	287	202100	9927800	-1872
26	197055	9931700	-1876,3	157	196100	9928700	-1875,4	288	202300	9927600	-1878,7
27	196900	9931900	-1881,6	158	196255	9928600	-1873	289	202500	9927000	-1902,9
28	196755	9932155	-1880,1	159	195700	9928600	-1881,4	290	202100	9926400	-1889,5
29	196655	9932400	-1883,1	160	195700	9928600	-1880,4	291	201900	9925400	-1893,7
30	196555	9932600	-1883,5	161	195800	9928800	-1870,4	292	201700	9924300	-1882,1
31	196800	9928900	-1856	162	195700	9928800	-1881,8	293	201400	9924800	-1895,1
32	197100	9928900	-1885,4	163	195300	9928900	-1889,7	294	200800	9924000	-1899,8
33	197400	9928900	-1869,1	164	195200	9929100	-1874,9	295	200200	9923700	-1901,7
34	197600	9928800	-1872,7	165	195400	9929100	-1889,7	296	199800	9923300	-1902,4
35	197800	9928800	-1858,8	166	195455	9929040	-1888,3	297	199500	9922800	-1884,6
36	197900	9928800	-1844,2	167	195500	9929300	-1885,6	298	199300	9922400	-1881,3
37	197900	9928900	-1858,3	168	195500	9929400	-1875,6	299	198100	9930700	-1879,1
38	197700	9929200	-1845,6	169	195400	9930100	-1892,9	300	198300	9930900	-1875
39	197700	9929400	-1845,2	170	195100	9930100	-1896,3	301	198600	9930900	-1870,1
40	197600	9929500	-1849,4	171	195000	9930000	-1893,6	302	198600	9931300	-1837,8
41	195100	9929200	-1827,5	172	194900	9930100	-1894,2	303	198300	9931200	-1877
42	195200	9929400	-1864	173	194800	9930300	-1893	304	198300	9930500	-1870,7
43	194900	9929500	-1887,9	174	194700	9930400	-1898,5	305	198600	9930500	-1866,2
44	194700	9929500	-1894	175	194800	9930300	-1904,5	306	199000	9930500	-1870,3
45	194200	9929500	-1909	176	194700	9930200	-1888,5	307	199300	9930600	-1834,5
46	194100	9929400	-1902,1	177	194600	9930055	-1891,5	308	199700	9930900	-1876,3
47	193800	9929600	-1913	178	194500	9930000	-1897,6	309	198700	9929700	-1873,4
48	193700	9929200	-1910,6	179	195000	9929600	-1898,6	310	199200	9929600	-1855
49	194600	9929900	-1900	180	195200	9929900	-1908,9	311	199500	9929900	-1875,2
50	194455	9930100	-1897	181	195300	9930100	-1898,7	312	199800	9930100	-1876,1
51	194100	9930300	-1891,4	182	195300	9930200	-1896,8	313	200100	9930600	-1881,8
52	193800	9930400	-1856,9	183	195200	9930000	-1872,3	314	200500	9930600	-1865,8
53	193700	9930600	-1880,2	184	195400	9929800	-1890,1	315	200500	9931100	-1862,6
54	193500	9930800	-1906	185	193600	9931300	-1922,4	316	200700	9931400	-1874
55	193400	9931000	-1886,2	186	193500	9931200	-1911,1	317	198900	9929700	-1865
56	193300	9930700	-1902,6	187	193500	9931100	-1902,9	318	200700	9930600	-1841
57	193100	9930700	-1894,5	188	193500	9930900	-1921	319	200900	9930500	-1865,9
58	193100	9930900	-1899,6	189	193600	9931900	-1921,3	320	201200	9930400	-1880,1
59	192900	9931000	-1852,8	190	193500	9931900	-1902,6	321	201500	9930300	-1882,9
60	192900	9931200	-1875,8	191	193500	9931800	-1922	322	201900	9930200	-1883,1
61	193000	9931355	-1912,6	192	194600	9929600	-1887,4	323	201800	9930500	-1884,1
62	193155	9931510	-1901,6	193	193600	9928800	-1877,7	324	201700	9930700	-1875,5
63	193255	9931620	-1905,8	194	193400	9928800	-1844,3	325	201700	9930000	-1901,7
64	193400	9931700	-1912,4	195	193200	9928600	-1910,1	326	199500	9929500	-1836,3

No.	Easting	Northing	CBA	No.	Easting	Northing	CBA	No.	Easting	Northing	CBA
65	193500	9931700	-1922,6	196	193100	9928500	-1905,2	327	199800	9929300	-1853,9
66	193600	9931700	-1929,1	197	193700	9930300	-1879,7	328	200055	9929200	-1817,7
67	194400	9929900	-1909,2	198	190700	9936900	-1946,6	329	200500	9929000	-1860,5
68	194300	9929900	-1905,8	199	196500	9933100	-1890,8	330	201000	9929000	-1865,7
69	194100	9929800	-1904,7	200	196600	9933500	-1892,1	331	201100	9928900	-1883,5
70	193900	9929800	-1915,7	201	196400	9933700	-1894	332	201300	9929000	-1878
71	193700	9929600	-1901,4	202	196300	9933800	-1900,6	333	201600	9929100	-1876,6
72	193800	9929900	-1922,4	203	196200	9934000	-1900,2	334	201800	9929200	-1885,3
73	193900	9930100	-1913,9	204	196000	9934200	-1932,8	335	196755	9933020	-1880,7
74	193700	9930300	-1899,2	205	196500	9934700	-1891,6	336	197000	9933100	-1892,8
75	194400	9930300	-1892,3	206	196800	9935000	-1917,9	337	197400	9932900	-1890,5
76	194400	9930400	-1890,4	207	196800	9935700	-1884,2	338	197800	9933100	-1896
77	194300	9930500	-1893,2	208	196700	9936100	-1891,8	339	198100	9932700	-1898,1
78	194200	9930600	-1890,7	209	196600	9936500	-1905,6	340	198300	9932400	-1887,4
79	194100	9930700	-1881,8	210	196100	9936700	-1895,3	341	198300	9932200	-1894,2
80	193900	9930900	-1868	211	195700	9936700	-1902,6	342	198100	9931900	-1906,4
81	193700	9931100	-1905,3	212	195200	9936700	-1880	343	197800	9931600	-1898,6
82	193700	9931400	-1904,9	213	194800	9936500	-1898,3	344	199100	9932300	-1920
83	193700	9931500	-1895,8	214	194600	9936100	-1892,2	345	199100	9932300	-1916,2
84	194000	9931600	-1873,8	215	194600	9935600	-1875,6	346	197600	9933200	-1897
85	194300	9931500	-1898,1	216	194200	9936100	-1882,1	347	197800	9933400	-1893
86	194200	9931300	-1904,8	217	194800	9935800	-1885,7	348	198200	9933900	-1897,9
87	194200	9931200	-1894	218	193800	9936000	-1890	349	198600	9934000	-1903
88	194200	9931100	-1884,2	219	194500	9937900	-1897,7	350	198700	9934300	-1903,2
89	194400	9931000	-1895,4	220	193000	9936200	-1887,3	351	198100	9933700	-1897,8
90	194700	9930800	-1887,5	221	192700	9936100	-1887,5	352	197600	9933500	-1892,2
91	194300	9931700	-1902	222	192400	9936400	-1901,8	353	197300	9933700	-1881,4
92	194300	9931800	-1892,9	223	192300	9936300	-1902,9	354	197100	9933700	-1878,6
93	194600	9931075	-1893,7	224	191900	9936400	-1907,5	355	196600	9934100	-1895,9
94	194255	9931020	-1883,6	225	191500	9936600	-1913,1	356	196800	9934600	-1915,5
95	194875	9930855	-1875,1	226	191200	9936600	-1935	357	197000	9934500	-1886,6
96	195000	9930990	-1857,4	227	190800	9936800	-1941,4	358	196800	9934600	-1902,4
97	195055	9931100	-1872	228	190500	9937300	-1961,2	359	196900	9935300	-1848,4
98	195100	9931170	-1875,3	229	190400	9937500	-1955,4	360	197100	9935200	-1860,5
99	195200	9931255	-1873,9	230	190200	9937600	-1942,3	361	197500	9935200	-1870,9
100	194800	9931200	-1876,6	231	196600	9928200	-1856,3	362	197800	9935200	-1874,5
101	195655	9931180	-1879,6	232	196800	9928300	-1842,8	363	197700	9935500	-1889,4
102	194755	9931300	-1883,1	233	197000	9928310	-1792,7	364	197600	9935800	-1898,1
103	195755	9931255	-1878,8	234	197200	9928320	-1840,4	365	183020	9941500	-2025,6
104	194800	9931530	-1885,8	235	197400	9928325	-1838,8	366	183340	9942010	-2000,6
105	195700	9931420	-1771,8	236	197490	9928370	-1844,7	367	183330	9943100	-2011,1
106	194800	9931700	-1890,4	237	197700	9928410	-1857,4	368	183330	9944255	-1977,9
107	195655	9931560	-1876,5	238	197760	9928500	-1844	369	183330	9946030	-1982,5
108	195460	9931540	-1880,6	239	194600	9932000	-1879,1	370	185220	9946060	-1974,7
109	194700	9931900	-1892,7	240	194600	9932200	-1886,6	371	187490	9946510	-1943,3
110	195466	9931740	-1880	241	194900	9932200	-1871,7	372	187610	9946720	-1912,9
111	195500	9931870	-1878,9	242	195100	9932200	-1887,6	373	191360	9947030	-1894,8
112	193300	9931800	-1915,2	243	194400	9932100	-1887,1	374	193755	9946810	-1877,6
113	193300	9931900	-1907,9	244	194300	9932010	-1897,7	375	185760	9946255	-1968,4
114	192700	9931800	-1918	245	194300	9932100	-1901,7	376	185770	9944730	-1989,6
115	192500	9931800	-1904,1	246	194300	9932300	-1900	377	185740	9942790	-2009,4
116	192600	9931700	-1884,2	247	194200	9932300	-1884,7	378	185090	9941755	-1947,4
117	193100	9930700	-1907,5	248	193900	9932700	-1887,3	379	186840	9941940	-2002,1
118	193000	9930600	-1910,9	249	193810	9932800	-1878,8	380	187510	9942000	-2001
119	192700	9930500	-1906	250	193800	9933100	-1925,5	381	187500	9942610	-1971,1
120	192500	9930600	-1886,8	251	193810	9933300	-1918,2	382	187520	9944870	-1961
121	194000	9930600	-1900,5	252	193300	9932000	-1900,4	383	190420	9946740	-1913,4
122	194000	9930500	-1908,4	253	193100	9932200	-1901,7	384	190410	9946710	-1896
123	195100	9929300	-1905,8	254	192830	9932200	-1895,7	385	190455	9944990	-1888,2
124	195100	9929200	-1899,3	255	192900	9932700	-1930,1	386	190500	9943600	-1910,7
125	195000	9929300	-1903	256	192800	9933000	-1895,8	387	188760	9943240	-1935,3
126	195000	9929255	-1906,7	257	192600	9933500	-1886,3	388	187340	9947710	-1914,6
127	194980	9929120	-1892,7	258	192300	9933700	-1885,4	389	187500	9948560	-1896,1
128	194500	9929130	-1919,6	259	191800	9934000	-1851,7	390	188540	9948580	-1868
129	194855	9929100	-1901,9	260	191700	9934000	-1831,9	391	189210	9948610	-1863,6
130	194800	9929080	-1911,1	261	191600	9934300	-1800,6	392	183420	9947255	-1959
131	194755	9928900	-1886,3	262	191400	9934400	-1788,3				

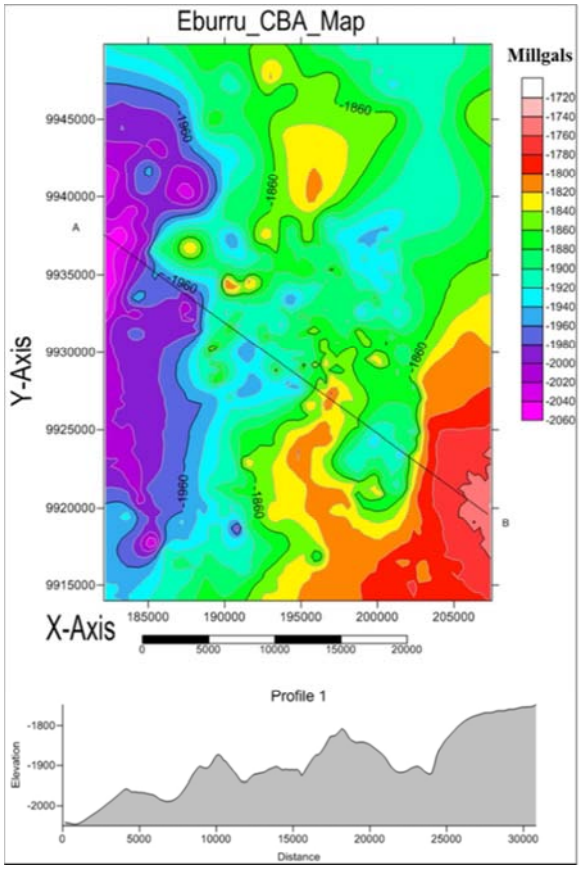

Figure 6. *Gravity map showing the density of Eburru geothermal area, along cross-section A-B.*

From the Complete Bouguer Anomaly (CBA) map, we can notice that the density increases from the West to the East. This high density in the East can be attributed to presence of intrusion (dykes, sills, etc.) or heat source. From the profile, we have three high density bodies. This shows the best drill target.

6. Conclusion and Recommendations

From the gravity analysis, along the section A-B, the density increases from the west to the east.

From the interpretation of the gas geothermometers the calculated temperature was 270°C, which almost confirms to the quartz geothermometer which gave the calculated temperature as 255°C.

We can conclude that the Eburru geothermal reservoir temperatures range between 255-270°C.

More Geological studies, geochemical studies and geophysical have to be carried out in Eburru geothermal prospect to know the actual potential of Eburru geothermal Field.

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